

WHAT IS CLAIMED IS:

1. A method of detecting a consumption status of liquid contained in a liquid container, comprising steps of:

preparing a detection device having a piezoelectric element and attaching said detection device on a desired position of the liquid container so that at least a part of said detection device contacting the liquid;

measuring a residual vibration of said detection device;
and

detecting the consumption status of the liquid contained in the liquid container on the basis of a result of the measurement of the residual vibration.

2. The detection method according to claim 1, further comprising a step of activating said detection device to cause a vibration.

3. The detection method according to claim 1, wherein said residual vibration measurement step comprises a step of measuring a frequency of the residual vibration.

4. The detection method according to claim 1, wherein said residual vibration measurement step comprises a step of measuring a resonance frequency of the liquid surrounding the detection device.

5. The detection method according to claim 2, wherein said measurement step is operated after a predetermined time period has elapsed from the activation step.

6. The detection method according to claim 2, wherein said measurement step is operated after the vibrations of the detection device several times.

7. The detection method according to claim 1, wherein said measurement step comprises a step of measuring time period in between a predetermined plurality of peaks of the residual vibration.

8. The detection method according to claim 1, wherein said measurement step comprises a step of measuring number of peaks of the residual vibration within a predetermined time period.

9. The detection method according to claim 1, wherein said measurement step comprises a step of measuring a counterelectromotive voltage generated by the detection device in accordance with the residual vibration thereof.

10. The detection method according to claim 3, further comprising steps of:

measuring previously a first frequency value of the residual vibration of the detection device when the liquid container is full of liquid, said frequency is regarded as a reference frequency value;

measuring a second frequency value of the residual vibration of the detection device when liquid in the liquid container is consumed;

comparing said reference frequency with said second frequency; and

judging the consumption status of the liquid contained in the liquid container in accordance with a result of said comparing step.

11. The detection method according to claim 3, wherein said residual vibration frequency measurement step comprises a step of measuring a plurality of resonance frequency modes of the residual vibration of the detection device.

12. The detection method according to claim 11, wherein said measurement step comprises steps of measuring a first and a second resonance frequency modes, and recognizing said two resonance frequency modes as a single pattern.

13. A liquid container comprising:
a housing containing therein liquid;
a liquid supply opening formed in said housing; and
a detection device having a piezoelectric element, said detection device generating a detection signal in accordance with a residual vibration of said piezoelectric element, said detection signal indicating a consumption status of the liquid contained in said housing.

14. The liquid container according to claim 13, wherein said detection device is activated to generate a vibration.

15. The liquid container according to claim 13, wherein said detection signal represents a frequency value of the residual vibration of the detection device.

16. The liquid container according to claim 13, wherein said detection signal represents a resonance frequency of the liquid surrounding the detection device.

17. The liquid container according to claim 13, wherein said detection device vibrates at least one resonance frequency mode.

18. The liquid container according to claim 13, wherein said detection signal represents a counterelectromotive voltage generated by said detection device in accordance with the residual vibration thereof.

19. The liquid container according to claim 13, wherein the liquid container is an ink cartridge for an ink jet printer.

20. A detection control circuit for detecting a consumption status of liquid contained in a liquid container by a detection device having a piezoelectric element, the circuit comprising:

a measurement circuit segment for measuring a residual vibration of the detection device; and

a detection circuit segment receiving a signal from said measurement circuit segment and outputting a signal indicative of the consumption status of the liquid contained in the liquid container on the basis of the output signal of said measurement circuit segment.

21. The detection control circuit according to claim 20, wherein said measurement circuit segment measures a frequency of the residual vibration of the detection device.

22. The detection control circuit according to claim 20, wherein said measurement circuit segment measures at least one resonance frequency of the liquid surrounding the detection device.

23. The detection control circuit according to claim 20, wherein said measurement circuit segment measures a counterelectromotive voltage generated by the detection device in accordance with the residual vibration thereof.

24. The detection control circuit according to claim 20, wherein said measurement circuit segment comprises an amplifier, said amplifier comprises a PNP type transistor and a NPN type transistor which complementarily connecting with said PNP type transistor, and emitter of said PNP type transistor and an emitter of said NPN type transistor connect with each other.

25. The detection control circuit according to claim 24, wherein a drive voltage generated between a point connecting between the emitter of said NPN type transistor and said PNP type transistor and the ground is applied to the detection device.

26. The detection control circuit according to claim 20, wherein said measurement circuit segment comprises an amplifier, said amplifier comprises a P-channel field effect transistor and a N-channel field effect transistor which complementarily connecting with said P-channel field effect transistor, and a source of said P-channel transistor and a source of said N-channel transistor connect with each other.

27. The detection control circuit according to claim 26, wherein a drive voltage generated between a point connecting between the sources of said N-channel FET and said P-channel FET and the ground is applied to the detection device.

28. The detection control circuit according to claim 20, wherein said detection circuit segment comprises a counter for counting number of the vibration of the residual vibration within a predetermined time period, and said detection circuit segment judges the liquid consumption status in accordance with the counted value.

29. The detection control circuit according to claim 20, wherein said detection circuit segment comprises a counter for counting number of clocks within a time period where the residual vibration vibrates a predetermined number of times, said clock has a cycle shorter than the vibration cycle of the residual vibration.

30. The detection control circuit according to claim 28 or 29, wherein said detection circuit starts counting the number of vibration of the residual vibration after a predetermined number of vibrations of the residual vibration has occurred.

31. The detection control circuit according to claim 20, wherein said detection circuit segment outputs a signal representing whether the liquid container connects with said measurement circuit.

32. The detection control circuit according to claim 20, wherein said measurement circuit segment further comprises a plurality of amplifiers connecting with a respective one of a plurality of the detection devices to supply a drive voltage, and said detection circuit segment receives a plurality of signals from said measurement circuit segment corresponding to the respective detection device and outputting a plurality of signals indicative of the consumption status of the liquid contained in the liquid container on the basis of each of the output signals of said measurement circuit segment.

33. The detection control circuit according to claim 20, further comprising a control circuit segment for controlling an operation to consume the liquid contained in the liquid container in accordance with the output signal of said detection circuit segment.

34. The detection control circuit according to claim 33, wherein said control circuit segment comprises an information memory control circuit segment for reading out the liquid consumption status stored in a memory device attached to the liquid container and writing in the memory device information relating to the liquid consumption status detected by said detection circuit segment.

35. A computer-readable recording medium storing thereon a program for a control circuit installed in an ink jet printer to detect a consumption status of ink contained in an ink cartridge by using a detection device having a piezoelectric element attached on a desired position of the ink cartridge, the program comprising steps of:

measuring a residual vibration of the detection device; and
detecting the consumption status of the ink contained in the ink cartridge on the basis of a result of the measurement of the residual vibration.

36. The recording medium according to claim 35, further comprising a step of activating the detection device to cause a vibration.

37. The recording medium according to claim 35, wherein said residual vibration measurement step comprises a step of measuring a frequency of the residual vibration.

38. The recording medium according to claim 35, wherein said residual vibration measurement step comprises a step of measuring a resonance frequency of ink surrounding the detection device.

39. The recording medium according to claim 36, wherein said measurement step is operated after a predetermined time period has elapsed from the activation step.

40. The recording medium according to claim 36, wherein said measurement step is operated after the vibrations of the detection device several times.

41. The recording medium according to claim 36, wherein said measurement step comprises a step of measuring time period in between a predetermined plurality of peaks of the residual vibration.

42. The recording medium according to claim 35, wherein said measurement step comprises a step of measuring number of peaks of the residual vibration within a predetermined time period.

43. The recording medium according to claim 35, wherein said measurement step comprises a step of measuring a counterelectromotive voltage generated by the detection device in accordance with the residual vibration thereof.

44. The recording medium according to claim 37, further comprising steps of:

measuring previously a first frequency value of the residual vibration of the detection device when the ink cartridge contains full of ink, said frequency is regarded as a reference frequency value;

measuring a second frequency value of the residual vibration of the detection device when ink in the ink cartridge is consumed;

comparing said reference frequency with said second frequency; and

judging the consumption status of the ink contained in the ink cartridge in accordance with a result of said comparing step.